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LIGHTING DATA

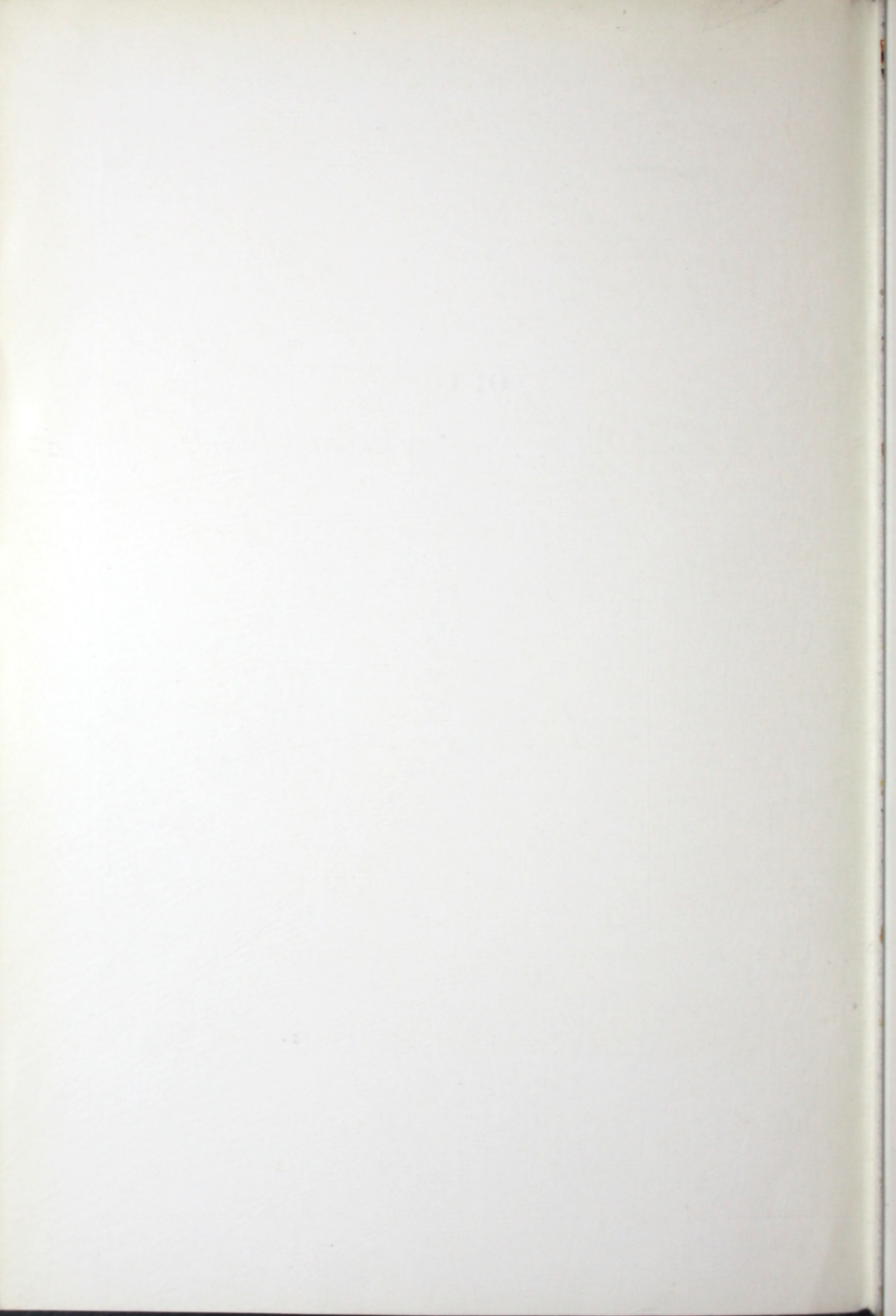
BULLETIN LD 134A



Lighting of the Metal Working Industries

EDISON LAMP WORKS
OF GENERAL ELECTRIC COMPANY

GENERAL SALES OFFICE
HARRISON, N. J.



The Lighting of the Metal Working Industries

Information Compiled by
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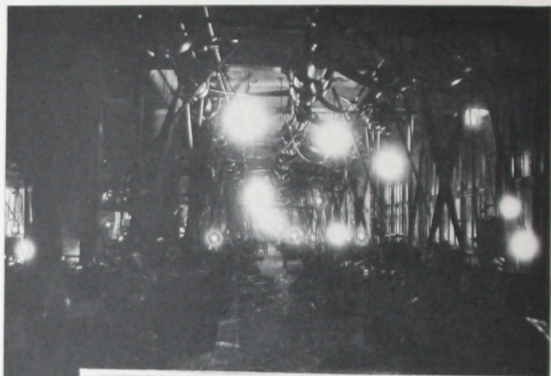
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For information regarding MAZDA lamps and lighting questions, refer to the nearest sales office.

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"THE OLD AND THE NEW"

These night photographs present a striking comparison of the lighting in the automatic screw machine department of a large plant before and after being modernized. In the new installation four RLM Standard Dome reflectors carrying 100-watt MAZDA lamps, mounted 10 feet above the floor in each 18 by 18 foot bay, provide an intensity over the working plane of eight foot-candles. The uniformity of light distribution, absence of harsh shadows, and general cheerful appearance of the shop are worthy of note.

The Lighting of the Metal Working Industries

*Information Compiled by A. L. Powell and W. H. Rademacher
Engineering Department*

Introductory

Adequate and properly applied artificial illumination is an indispensable adjunct to successful plant operation. Numerous investigations and tests have proved conclusively that artificial lighting may be a means to the promotion of safety, increased



WHERE NIGHT IS BETTER THAN DAY

This general machine shop is lighted to an average intensity of twelve foot-candles.

The equipment consists of RLM Standard Dome reflectors with 200-watt white bowl MAZDA lamps on 10- by 12-foot centers, 11 feet above the floor.

production, reduced spoilage, better sanitation, and a high morale among employees. In other words, good lighting and industrial efficiency are inseparable. A detailed discussion of these relations is presented in Bulletin Index 17.

Contrary to the view held by some, artificial light is quite necessary regardless of whether work is carried on at night or during the daytime. In the former case the necessity is obvious—in the

latter it may be pointed out that during the daytime working hours throughout the entire year there is an average of approximately two hours per day during which artificial illumination must be used because of failing daylight—due to the cloudiness or the coming of evening. In addition, there are many plants which require artificial light throughout the day because of building construction.

Methods of Lighting

There are three methods of lighting which may find application in the metal working industries. These are designated with regard to the placement of lighting units, and, with their relative advantages and disadvantages, are as follows:

General or Overhead Lighting

Such a system consists of light sources mounted overhead and insofar as possible symmetrically arranged to produce approximately uniform illumination throughout a given area. If properly designed, such lighting makes possible good vision in any location or position, and, where overhanging machine construction does not prevent, is the ideal method of factory lighting. With this scheme relatively few outlets are required and efficient MAZDA C lamps of the larger sizes can be used.

Group or Localized General Lighting

Such a system consists of light sources mounted overhead but located with respect to machines or benches in order to provide an increased intensity or preferred direction of light for major working positions. Where work is confined to certain sections of a plant or where overhanging machine construction exists, this scheme of lighting is to be preferred.

Local Lighting

Such a system consists of a light source for each working position, mounted close to the work so that illumination is concentrated over a small area, and provides no general lighting. Where extremely high intensities of light are required, local lighting in conjunction with general illumination is desirable. Wherever one of the other forms of lighting previously described is applicable, it should always be used in preference to local lighting. The major objections to local illumination under any condition other than that described above are as follows:

1. High installation cost—due to the large number of outlets, lamps, reflectors, and wiring material required.
2. High maintenance cost—due to the large number of outlets which must be serviced, high breakage through handling of lamps by operators, theft due to the accessibility of lamps, and wiring troubles caused by manipulation of lamps, reflectors, and connections on the part of the operators.



THIS SYSTEM OF LIGHTING PROVIDES FOR ALL CLASSES OF WORK

Illumination for general machine work is supplied by 200-watt *MAZDA* lamps in Glassteel Diffusers mounted 13 feet above the floor on 8- by 15-foot centers. An average intensity of ten foot-candles results from this system. The exacting vise and bench work is provided with supplementary local lighting in the form of deep bowl reflectors mounted on adjustable arms. The intensity at the vises is well over thirty foot-candles.

3. Greater eye fatigue, accident hazard, and poorer appearance of room, combined with less cleanliness when no general lighting is used, due to spotty lighting and relatively dark areas above the light source. The light sources, being under the control of the operator, are frequently tied in a position which suits the fancy of one and creates a condition of glare objectionable to another.

General Considerations

It has been said that light may be produced by lamps without reflectors, but not by reflectors without lamps. This statement is true, but lamps without reflectors not only waste power, but also are a cause of ineffective lighting due to glare. The purposes of reflectors are two-fold—to distribute efficiently the light which is created by the lamp on the working plane, and to protect the eyes of the workmen from the brightness of the lamp filament. Reflectors may also be designed so as to lend an element of protection to the lamp, as in the case of metal guards and vapor-proof enclosing globes.

In reflecting equipment, as in practically all other devices used in the metal working industries, permanence, simplicity, durability, efficiency, and ease of maintenance are essential requirements.

To obtain permanency the equipment must be rugged in construction, of such material, in the case of steel mills and foundries, that the action of gases will not rapidly depreciate its reflective powers, and of such construction that the dust particles will not settle to a great extent on the reflecting surfaces.

It must be simple in design and not made up of complicated parts requiring great care in assembling and cleaning.

Practically all types of reflectors discussed in Bulletin Index 22 "Reflectors for Incandescent Lamps" have been applied for the lighting of metal working plants. The application of many of the types is shown in the accompanying illustrations.

The RLM Standard Dome reflector is the most widely used type for general or localized general illumination. It gives a very desirable distribution of light over horizontal surfaces with adequate illumination on the vertical surfaces. It is efficient, easy to clean, and so designed that direct glare is reduced to a satisfactory minimum.

The Glassteel Diffuser has somewhat similar properties, but is so constructed as to transmit upward a portion of the light generated by the lamp. This produces more cheerful surroundings and promotes safety in the operation of belting and shafting. The large opal glass enclosing globe which surrounds the lamp promotes high diffusion with resulting low brightness and extremely soft shadows, making this unit particularly well adapted to the illumination of such work as is carried on on polished surfaces or on intricate machinery.

The deep bowl metal reflector gives a lower cut-off than the RLM—in other words, the lamp is not visible at the same angle. This very fact, however, tends to reduce the amount of light on vertical surfaces and, although there may be excellent illumination on the working plane, a room often appears dull and cheerless when bowl reflectors are employed. Light colored surroundings reflecting and diffusing the light tend to overcome this difficulty. The deep bowl reflector, because of its low cut-off, is especially serviceable in local lighting with low hung lamps.



**A VERY CHEERFUL SHOP RESULTS WHEN TRANSLUCENT REFLECTORS
ARE USED**

An intensity of eight foot-candles is provided for this group of automatic lathes by 150-watt MAZDA C lamps in deep bowl prismatic glass reflectors on 10½-foot centers 13 feet high. Accidents through running into the long bar stock projecting from the machines are easily avoided.

For local lighting at machines where there is considerable overhang of parts, and where light must be directed obliquely to the working point, or where it is essential to have adjustable mounting for the light source, an adjustable arm type lighting unit carrying a small deep bowl reflector should be employed.

Angle metal reflectors are used where especially high illumination is required on vertical surfaces and where lighting units must

be located on the side walls or columns. They are frequently placed below the crane track and should generally be supplemented by overhead units. It is seldom, if ever, good practice to mount angle type units at a height less than 15 ft. above the floor, for a low mounting height usually results in the light source being within the line of vision of workmen and the resulting glare is a menace to eye comfort and safety. The spacing centers should be a distance approximately equal to one-half of the building width.



MERE HEIGHT DOES NOT PRECLUDE GOOD LIGHTING

Machine shops with very high ceilings may be efficiently and effectively lighted if the correct type of reflector is selected. The shop illustrated, which has a 30-foot ceiling and glass windows as side walls, is very well lighted by prismatic glass reflectors and 500-watt clear MAZDA C lamps on 15- by 20-foot centers. The intensity of illumination on the working plane is about ten foot-candles. It will be noted that supplementary lighting is provided for the roofed-over tool crib.

Prismatic and mirrored glass reflectors also find application in plants of the type under discussion. These can be very efficient and give suitable distribution of light. While it is evident that the likelihood of breakage is much greater than where metal reflectors are employed, the hazard is not as great as is often assumed. Where buildings are extremely high and surroundings relatively

dark in color, it is desirable to use a type of unit which projects the light from the lamp strongly downward. Reflectors which are particularly adapted to this service are found in those of prismatic and mirrored glass construction.

Wherever units are mounted above the craneway, suitable units on the same or equivalent centers should be mounted on the bottom of the crane bridges so that ample light will be provided at all points at all times regardless of the crane position.

It will sometimes be found that there is not sufficient clearance between the crane and roof truss to permit the mounting of units from the bottom of the trusses. In such cases the units may be satisfactorily mounted by employing a support in the form of a "Z."

In some buildings, particularly those of the older type, considerable vibration is present and is transmitted through the structure, in the case of rigidly mounted units, to the lamps with such magnitude that excessive filament breakage results. By using a flexible mounting and, in the cases of extremely severe vibration, a spring suspension, trouble due to this cause may be practically eliminated. There are on the market several commercial cushion hangers which are adapted to this service.

Enclosing or semi-enclosing units of opalescent or diffusing glass find some application in manufacturing operations and are especially suitable for the lighting of office spaces. They produce excellent diffusion with a slight sacrifice in efficiency. A room so lighted is generally agreeable and attractive. Conditions in a metal working plant are generally such as to make expedient the installation of indirect systems of lighting, but if unusually clean surroundings prevail the qualities of indirect lighting warrant consideration for some classes of work, particularly those in which high diffusion and a minimum of reflected glare is essential.

In the yards and thoroughfares the various types of standard street lighting units meet the requirements. These are described in detail in Bulletin Index 91, "Street Lighting with MAZDA Lamps." The radial wave reflector, for example, is inexpensive, efficient, and produces a wide spread of light. Refractor and diffusing globe equipments have their field, while the weatherproof type RLM Standard Dome is particularly useful in providing higher intensities over rather restricted areas where intensive work is being done.

Floodlighting devices find use where lighting outlets must be located at a considerable distance from the point to be illuminated. Care should be taken in the placement of these units so that the workmen will not be facing the light. Such a condition will be dangerous from the standpoint of glare. With floodlighting it is desirable to direct beams from opposite directions at a given point as this practice tends to prevent sharp shadows. Care must be taken in the mounting of overhead yard lighting units so that they will not interfere with the operation of locomotive cranes as they move about the yards.

Lamps used in open bottom reflectors mounted less than 20 ft. above the floor should be of the diffusing bulb, i.e., inside frost or white bowl type, in order to insure a minimum of glare and to make any shadows that do exist soft and feathery. Units mounted above 20 ft. may employ the clear lamp.

For use in drop lamps or portables the "Rough Service MAZDA" lamps are desirable. These lamps are designed, primarily, for knock-about service and are available in the 50-watt size with the inside frosted bulb. They are as strong as the old carbon lamp which was sometimes used for this service, and are far superior in quantity and quality of illumination.

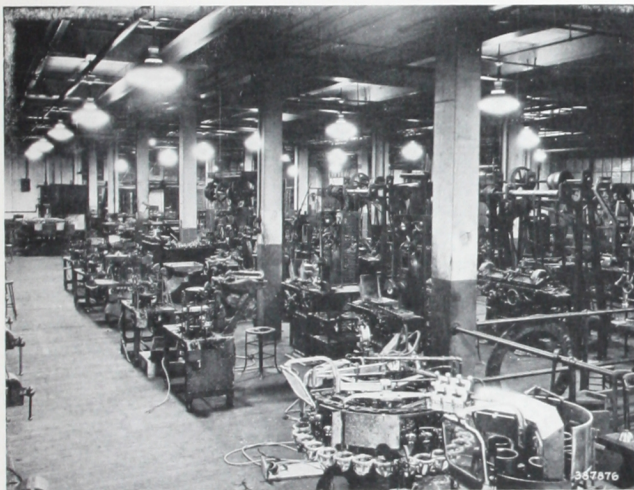
Where a demand is experienced in the metal working industry for light of a color character approximating daylight, as in the selecting of brass and other alloys by color, the MAZDA Daylight lamp is of proved value and should be used. For exacting color identification there are available standard types of color identification units which utilize the light from a clear MAZDA lamp passed through a specially selected filter plate. Such units may be obtained to give practically any degree of daylight desired. For more detailed information on this general subject refer to Bulletin Index 3, "Artificial Daylight for Merchandising and Industry."

Whatever system of illumination is chosen, it is good practice to provide light colored walls and ceilings and to refinish these at frequent intervals. Thus light which would otherwise be wasted is conserved.

The importance of a well-supervised, carefully planned system of cleaning lamps and reflectors cannot be over-emphasized. Many a complaint of poor lighting conditions is due to a marked diminution in intensity resulting from an accumulation of dirt and dust. The effects of this are far greater than casual thought would indicate, and the shop superintendent is urged to study

Bulletin Index 14, "The Effect of Maintenance and Color of Surroundings on Resultant Illumination."

In many plants lighting circuits are not separate from power circuits and 220-volt service is employed with either 220-volt lamps, or two 110-volt lamps in series. Although such operation may represent an initial economy in copper as compared to a 110-volt system the disadvantages, higher lamp cost, lower lamp efficiency,



A PLEASANT SHOP IN WHICH TO WORK

One outlet per bay supplying a 500-watt MAZDA C lamp equipped with a Glassteel Diffuser provides well distributed illumination averaging twelve foot-candles in this machine shop. The upward light from these units, in conjunction with the light ceiling and side walls, makes cheerful working conditions.

and inherently less rugged lamp structure more than offset this slight gain, as pointed out very clearly in Bulletin Index 4, "110 *vs.* 220-volt Circuits from the Standpoint of Lighting Service."

The disadvantage of operating two lamps in series and the superiority of 110-volt (nominal) lamps for general lighting service are too well known to require discussion here. The practice of operating lighting circuits from direct-current power feeders, particularly where heavy loads are thrown on and off the line, is extremely objectionable as severe voltage fluctuation is prevalent due to the con-

stantly changing load on the generators. This results in bad flickering of the lights and, of course, affects the life and light output of the lamps. Furthermore, the shutdown of a power unit may mean throwing the plant in darkness at the very time when adequate lighting is most required. Substantial economies and convenience can be effected by the use of 110-volt lamps, and in new installations this voltage should unquestionably be adopted. In the case of those now in operation a thorough investigation should be made of the various simple and economical means available for changing, with a view toward ascertaining the advisability of adopting the 110-volt service.

Separate lighting circuits, or, in the case of alternating-current drive, high-voltage distribution with a step-down through transformers, with buck and boost regulators where voltage variation is extreme, are best adapted to the producing of satisfactory lighting.

Machine Shops

There are two characteristic types of buildings devoted to metal working which require different methods of lighting:

- A. Those having relatively high ceilings, 20 to 60 feet, with a crane traveling the length of the bay (center bay).
- B. Those with low ceilings, 10 to 15 feet, with machines frequently driven by overhead shafting (side bays).

In the first case units must be hung high, above the crane travel, or placed on the supporting columns below the crane track. In the second case the mounting height is necessarily low, and shafting and belts are likely to cast shadows.

Larger, rougher work is usually carried on in the center bay and finer work in the side bays.

Overhanging parts of many metal working machines tend to cast shadows on vital areas unless the proper direction of predominant light is secured. This question is of particular importance in the room where units must be hung low, for any individual machine generally receives most of its light from only one unit. In the other case with lamps well above the floor each machine receives light from a number of units, thus reducing the tendency toward dense shadows.

Bench Work

Many processes are carried on at benches, such as assembling small parts, soldering, sorting, filing, general vise work, inspection, etc. It is apparent that different intensities of illumination are required.

Benches fall in two general groups, single benches two or three feet wide along the walls, and single or double benches away from the walls.

Single benches along the walls should be lighted by a row of lamps about six inches in from the forward edge of the bench, spaced on 6- to 10-foot centers with from 40- to 100-watt MAZDA lamps in deep bowl or RLM Standard Dome reflectors. The size of lamp will depend on the fineness of the work and the spacing of the vises or working points. It is desirable to locate units between



WELL LIGHTED BENCHES AND ASSEMBLY AREA

The lighting is furnished by 150-watt MAZDA C lamps in glass top dome reflectors, spaced on 8-foot centers. General illumination units are close to the 14-foot ceiling; those over the benches are at a height of 8 feet. The outlets are placed between vises. Notice particularly the even distribution of the light, and the clearness of detail.

vises rather than directly above them for, with this arrangement, light is received from each side and the operator is less likely to cast a shadow on the work. The units for bench lighting should be hung about five feet above the bench.

Where general illumination is used for the shop with outlets symmetrically spaced, as, for example, four outlets on 10-foot

centers per 50-foot bay, it is often feasible to move the first row of outlets two or three feet nearer the wall than would be employed for a strictly symmetrical arrangement. This method supplies satisfactory bench lighting with but little sacrifice of general illumination and with a minimum number of outlets as shown on preceding page.

For benches away from the wall, general illumination is quite satisfactory, if a fairly close spacing of outlets (not over 10- or 12-foot centers for ordinary conditions) is adhered to. Where the ceiling is very low or the work exacting, localized general illumination with the units arranged as suggested for benches along the wall is sometimes necessary. Again where minute parts are handled, as in the watch factory, or in very close inspection work, local lighting offers the most economical means of providing the high intensity (fifty foot-candles and upwards) which is necessary; this should, of course, be supplemented by general illumination.

The intensity for bench lighting depends on the type of work carried on and ranges from about six foot-candles for soldering to twenty foot-candles for accurate fitting of machine parts.

Machine Tool Work

There are a few processes—deep boring, punching and pressing of large blanks, lathe work on minute parts, such as watch mechanisms and the like—which require local lighting. With these few exceptions, machine tool work can be carried on most effectively with lighting from overhead units. This statement is borne out by numerous satisfactory installations in constant use. Many mechanics argue otherwise, thinking they cannot work unless there is a drop lamp directly over the tool, but this is largely a question of psychology. After a new system has replaced the old, everyone is usually enthusiastic in his praise, after becoming accustomed to the change.

The system to use for lighting machine tools depends on the type of building, as pointed out above.

There are many degrees of precision requiring different amounts of light and the MAZDA lamp with its wide range of sizes permits these conditions to be met easily.

The adequacy of a given lighting system may be quite readily checked by comparing the wattage provided per square foot of floor area with the figures given in the following table. The inten-

sities indicate good practice for the general lighting of machine tool work. The wattages are the minimum which should be employed with MAZDA lamps of the 150-200-watt sizes when used in efficient reflectors in machine shops of average size having surroundings of medium color, and normal conditions of depreciation.



LIGHT MAKES A SAFE PLANT

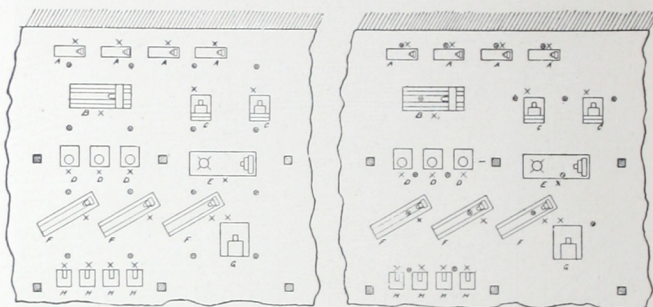
An excellent illustration of the practicability of general lighting for pressing and stamping operations, 200-watt white bowl MAZDA lamps in RLM Standard Dome reflectors mounted 10 feet above the floor on 8- by 10-foot centers provide an intensity of fourteen foot-candles.

Class of Work	Recommended Foot-candle Intensity	Minimum Required Watts per Sq. Ft.
Rough	4 to 6	0.7-1.0
Average	6 to 10	1.0-1.6
Fine	10 to 16	1.6-2.5

The RLM Standard Dome reflector is probably the most universally applicable unit for these conditions. The size of lamp will depend on the spacing and intensity desired. The spacing in turn

depends on the hanging height and size of bay. See Bulletin Index 13, "Calculation of the Lighting Installation," for data on determining the correct size of lamp to use.

A safe general rule for a satisfactory lighting installation in a machine shop of this nature is that the spacing between outlets should be about equal to the mounting height of the lighting units above the floor; thus, in a room where units would be mounted 20 feet, one per 20-foot bay would be satisfactory. If 40 feet high, one unit every two bays, while with the 10-foot mounting height, four units per bay would be desirable.



SECTION OF A TYPICAL MACHINE SHOP—STRICTLY GENERAL AND LOCALIZED GENERAL LIGHTING COMPARED

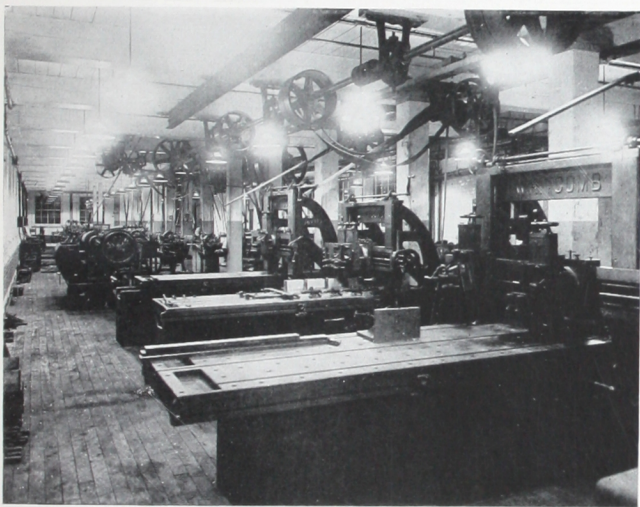
At the left is shown the outlet arrangement for strictly general illumination; at the right, the arrangement for localized general lighting.

A—Lathe (engine). B—Large Planer. C—Shaper. D—Drill Press. E—Lathe (turret). F—Automatic Screw Machine. G—Universal Miller. H—Emery Wheel and Buffer. O—Lighting Outlet. X—Position of Operator.

Where the ceiling is low, in order that the predominant light may come from the proper direction, particularly where much belting is present, it is most generally advisable to use localized general lighting, which is an intermediate practice between general and local lighting with common sense used in the placement of outlets. In the above diagram is shown the difference in arrangement between a general and a localized general lighting layout. In the case of the symmetrical arrangement, an analysis shows that many of the units are quite ineffective. For example, two are located directly behind the shapers in which position they would be of little use. The lighting of the lathes along the wall would be from the wrong direction—the headstock would cast a shadow

on the work. The analysis might be continued for the entire hypothetical arrangement. In the other half of the diagram lighting units are so arranged that, taking into consideration the position of each machine, the correct direction of light results.

One might make the criticism that this is nothing but an extravagant system of local lighting with a rather large lamp for each machine. On the other hand, one would be willing to grant that with our present standards, the use of four 150- or 200-watt



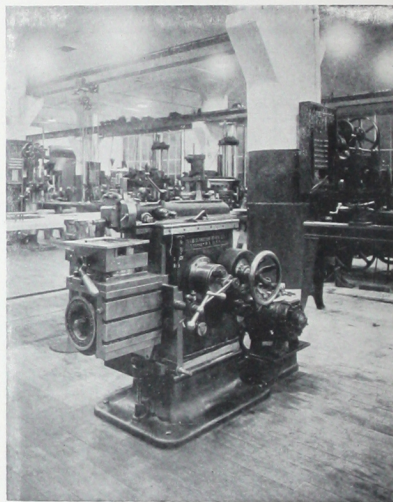
PLANING OPERATIONS ARE FACILITATED BY ADEQUATE LIGHTING

The excellent illumination on the beds of these planers is provided by 150-watt MAZDA C lamps in glass top dome reflectors mounted 10 feet above the floor on 8-foot centers, giving an intensity of over twelve foot-candles. The illuminated ceiling, produced by a small part of the light passing through the glass tops of the reflectors, gives a cheerful appearance to the room.

lamps in a 20-foot bay is not extravagant for general lighting. If the number of units in the four bays pictured is tallied, the general lighting system would show sixteen and the localized general, seventeen. An analysis similar to this of entire shops has been made time and time again, and the power required for a localized general lighting system checks up very closely with the power required for a general lighting system.

With such arrangement, each machine receives the kind of lighting it requires. All the advantages of general lighting are obtained and the disadvantages of local lighting eliminated.

Space will not permit a more detailed discussion of this question, which is of great importance, and it is hoped that the example given will indicate the method of attacking a lighting problem of this nature. One should not attempt to place the outlets for a machine shop with a relatively low ceiling without taking into consideration the location of the individual machines.



EXTENSION LAMPS ARE NOT NECESSARY TO LIGHT VERTICAL SURFACES

In this close-up view of a shaper installed in a large machine shop, the excellent illumination on the vertical part of the table should be noted, even though all lamps are close to the ceiling over sixteen feet from the floor.

The size of lamp required for this scheme depends as before on the fineness of the work. For rough work, 100-watt inside frosted MAZDA C lamps in RLM Standard Dome reflectors arranged approximately as shown will prove satisfactory, for average work, 150-watt white bowl MAZDA C lamps in RLM Standard Dome reflectors or clear lamps of the same size in Glassteel Diffusers, and for fine work, 200-watt units of the same types.

The following general rules indicate the desirable direction of light for the different types of machines:

Lathes—From above to the right of the chuck, very slightly forward.

Millers and Shapers—From above, in front, and preferably both sides.

Planers—Large machines above center of bed when at end of cutting stroke.



POWER PRESSES AS THEY APPEAR UNDER CORRECT GENERAL ILLUMINATION

An intensity at the work of nine foot-candles is provided by 500-watt MAZDA lamps in Glassteel Diffusers, mounted on 16- by 12½-foot centers, 13 feet above the floor.

Small machines—See shapers.

On planers where it is advisable to supply only moderate general illumination a small lamp with reflector may often be mounted near the tool.

Drill Presses—From above, in front, unless overhanging parts prevent, then slightly from the side.

Buffers, Grinding Wheels, etc.—Above the wheel, slightly forward.

Saws—In line with the saw, slightly forward.

Sheet Metal Work

Many of the processes in this type of plant are similar to those treated under Machine Tool Work.

Punching, pressing, and stamping, contrary to the general impression, can be satisfactorily illuminated by the overhead system with the predominating light from the front and from the left or right of the operator. It is true that where very large pieces are pressed, overhanging parts may be such as to make it quite essential to install drop lamps in the mechanism of the punch or press. On the other hand, the practice of having a bare unshielded



WHERE MOVING PARTS AND CUTTING EDGES MUST BE SEEN—THE SHEET METAL SHOP

A uniform distribution of outlets on 15-foot centers provides the requisite visibility in this sheet metal shop. 150-watt white bowl MAZDA lamps in dome type reflectors produce an average intensity of five foot-candles.

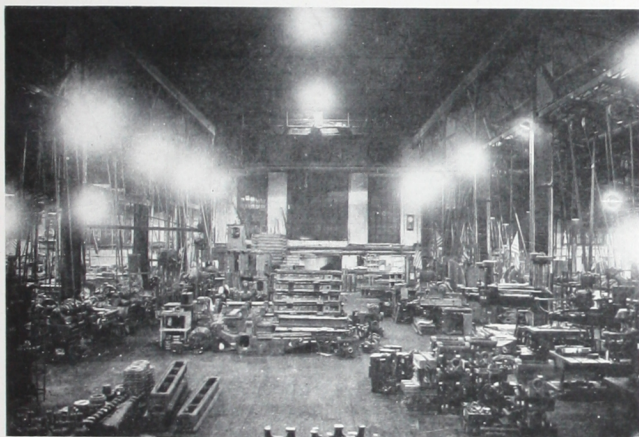
lamp lying on the bed of the press continually in the operator's field of view should be eliminated.

Under these conditions eye strain is severe, fatigue is increased, and the glare effect with attendant after-image is very likely to be the direct cause of a crushed hand.

Cutting, shearing, edge setting, rolling, polishing, burnishing and similar processes can be illuminated satisfactorily by a system of general lighting providing an intensity of from four to eight foot-candles, depending on the fineness of the work and the degree of accuracy required.

Assembling, Painting, Etc.

General illumination is entirely satisfactory for these operations as carried on in the metal working plant. This work usually takes place in the high center bay and the rules laid down for machine tool work in this area apply. The RLM Standard Dome reflector with clear MAZDA C lamps symmetrically spaced above the crane travel as pictured on page 30, or a combination of this unit and angle steel reflectors below the crane travel are the two most



SEVERAL TYPES OF INDUSTRIAL LIGHTING EQUIPMENT ARE USED HERE

Erecting bay of a machine tool plant at night. Above the crane travel, at a height of 50 feet, is a row of 1000-watt MAZDA C lamps in deep bowl steel reflectors. Below the crane travel, on the columns, are 300-watt MAZDA C lamps in angle type reflectors. In the lower-ceilinged side bays, 150- and 200-watt MAZDA C lamps in dome type reflectors are used. The illumination is of the strictly general type which is satisfactory in lighting high structures.

universally applicable methods of applying light here. The angle equipment has the advantage of directing the light from the side and producing excellent illumination on vertical surfaces. It is rarely adequate alone and should be supplemented by overhead units to prevent dense conflicting cross shadows. The above illustration indicates the results which are secured with the proper balance of light from different directions.

Steel Mills and Foundries

Large areas, high ceilings, dark surroundings, a smoky, dust-laden atmosphere and, particularly in steel mills, comparatively few workers, considering the spaces involved, are characteristic of all buildings. The dark surroundings make it desirable to use equipment which does not depend upon the walls or ceilings for reflection, but directs its light toward the work. The light, particularly in foundry work, should be of a character sufficiently



A WELL DESIGNED SYSTEM FOR STEEL MILL LIGHTING

This modern blooming and 18-in. merchant mill is lighted to an average intensity of 2.5 foot-candles by 750-watt MAZDA C lamps in bowl type steel reflectors on centers 40 by 50 feet, 40 feet high.

diffused to penetrate the molds, but should also have enough directional characteristic to bring out detail in its true perspective. Too great diffusion will give a flat appearance, so much so, perhaps, that the juncture of different planes may become indistinguishable and cause serious errors in molding.

Certain operators, particularly in foundry practice, feeling that they must keep their expenditure for lighting at an absolute minimum provide only a low intensity of general illumination, supplementing this by drop lamps. This practice is rarely satisfactory and a general lighting scheme is always to be preferred

for the reasons previously outlined. From a lighting standpoint a rather peculiar condition exists in this industry, in that, in the case of many operations, ample light at the working point is furnished by the incandescent metal undergoing manipulation. As, for example, at the soaking pits, blooming mills, charging and tapping floors of the open hearth. This situation, however, rather than permitting the use of a lower intensity of light, as might seem likely on hasty consideration, actually calls for a somewhat higher value than would otherwise be the case. The reason for this is that the incandescent metal is a source of high brilliancy upon which the



GOOD LIGHTING MEANS GOOD WORKING CONDITIONS

This night photograph of a Billet Cleaning, Chipping and Inspection Department shows a well distributed illumination of about four foot-candles, supplied from overhead by 500-watt deep bowl units and from the side by 300-watt angle units.

worker's gaze falls with a greater or less degree of intermittency. If the adjoining areas are dark the eye does not see clearly and, in fact, is blinded as it moves to the dark surroundings from the bright work, and vice-versa.

The wider the contrast in intensity the greater the degree of readjustment, and the longer the time required by the eye to adapt itself as it moves about. Thus production is lowered and the accident hazard increased if adequate general lighting is not provided. The illumination provided should permit the movement of the eye from place to place without the necessity of undue readjust-

ment, and should be of such an intensity that the workman can find tools, inspect and make repairs, carry on his work with celerity and comfort, and be safe from accident regardless of the presence or absence of hot light-giving metals. Furthermore, it should be free from objectionable glare and so distributed as to prevent harsh shadows.

The size of the area to be lighted and the permissible mounting height of the units will govern their number and arrangement. The rule of thumb as previously given, "the spacing of outlets should



IN THE COLD ROLLING DEPARTMENT THERE IS NO LUMINOUS METAL. Artificial light must provide illumination on the rolls as well as around them. In this modern steel mill an average intensity of four foot-candles is furnished by the overhead 750-watt dome and side 300-watt angle type units.

be about equal to the mounting height," may safely be followed. Naturally a few large units will be less expensive from the standpoint of both initial and operating expense, but if too few are employed uneven distribution and harsh shadows will result and the illumination will be far from satisfactory.

In buildings which are exceptionally high as compared to their width, and where the use of overhead cranes makes a very high hanging of overhead units necessary, a large volume of the light from the units would be incident on the upper wall area if the RLM or deep bowl reflector were used. With the customary dark condition of these surfaces the resulting reflection would be so low that the illumination secured would be only at the expense of a severe sacrifice in efficiency. In such interiors, therefore, it is usually desirable to employ units of the mirrored or prismatic glass type, mounted overhead, giving a concentrated distribution, or angle type enameled steel reflectors mounted below the crane rail and preferably supplemented by overhead general illumination. Under prac-



AN ADEQUATE LIGHTING SYSTEM FOR COARSE WORK

This annealing department in a building 50 feet wide is lighted to an average intensity of over two foot-candles by 750-watt MAZDA C lamps in RLM Standard Dome reflectors, with a single row of outlets on 50-foot centers, 36 feet above the floor. The work is comparatively coarse and the light sand aids materially in light reflection.

tically all other conditions the RLM Standard Dome or Glassteel Diffuser provide the desired characteristic light distribution.

The majority of the operations in typical steel mills, such as the charging and tapping of open hearth furnaces and blast furnaces, molding, stripping, mixing, rough shearing, soak pit, blooming mill, rail mill operation, pickling, galvanizing, tinning, dusting, etc., are of a rough and semi-automatic nature; over 80% of the output being completely processed without being touched by human hands. The lighting demands in most of these areas are fulfilled by a medium

intensity of general illumination. In other operations, such as cold rolling, inspecting, shearing by fine line, tin-plate sorting, structural steel layout, etc., a comparatively high intensity of well diffused light is essential, and higher wattages utilizing carefully planned general and localized lighting are best applied.

In rolling mills, where vertical face indicators and gauges must be distinctly visible at all times, it is advisable to supplement the general illumination with a localized unit of the angle or small flood type trained on the face of the indicator. Close shearing calls



COMBINATION OF GENERAL AND LOCAL LIGHTING AS INSTALLED
IN A PROGRESSIVE SHEET MILL

View taken in an opening and shear building lighted by 300-watt RLM Standard Dome units, uniformly distributed, providing general illumination of 2.5 foot-candles, and 200-watt local lights giving a higher intensity of 12.5 foot-candles at the shears.

for light which is of such direction as to illuminate the shear blades and cutting line. The proper position for the outlet is usually above and slightly in front of the operator. On large shears with considerable overhang localized general or local lighting is advisable.

Tin-plate sorting and inspection is undoubtedly the most exacting work encountered in sheet mill operation. A light source having a large area producing illumination of high diffusion is essential in order that trying specular reflections may be avoided and imperfections and flaws in sheets made readily visible. The Glassteel

Diffuser, applied as described under bench lighting, is well adapted to this service. In some mills where special study has been given to this problem, lighting units have been improvised making use of a dome-shaped deep box, finished on the inside with a white enamel paint, carrying lamps mounted in a trough around the lower edge in such manner as to throw their illumination up inside the box from where it may be diffusely reflected on to the inspection area. With such an arrangement the size of the light



A WELL LIGHTED FOUNDRY

An intensity of over five foot-candles is produced by 300-watt MAZDA C lamps in RLM Standard Dome reflectors on centers 10 by 40 feet, mounted on the ceiling trusses 35 feet above the floor.

source is virtually the entire area of the inside of the box, and the effect of an artificial sky is produced.

Vapor-proof fittings are desirable on the lighting units in the mixing houses and areas adjacent to the Bessemer converters, as minute particles of graphite from the operation of this equipment lodge on all exposed parts, and are frequently the cause of considerable trouble through short circuits where this precaution has not been taken.

In the Pickling Department, where more or less corrosive fumes are present, vapor-proof fittings are necessary.

As floor moulding and pouring are carried on within the same area, though at different times of the day, the lighting system will be the same. Moulding calls for the greatest accuracy and is usually done during the early hours of the day. For pouring and stripping the lighting demands are less exacting. This work is carried on during the latter part of the day when natural light is poor and the air in the foundry is full of dust and gases. However, if provision is made for proper light for moulding, a lower, though adequate, intensity will automatically prevail for pouring and stripping.



ADEQUATE LIGHTING MINIMIZES ACCIDENT HAZARDS

This picture of a typical foundry gives an idea of the uncertain footing and hazardous conditions that the worker in that industry encounters. With such lighting as here indicated, averaging five foot-candles, objects are clearly visible.

The lighting of bench moulding, machine moulding, and core making, which calls for some discrimination of detail, since the pieces turned out are usually small and must be accurately moulded, can best be accomplished by what is termed a "localized general" system. A high intensity is required along the row of machines or benches, while a lower illumination is sufficient for the remainder of the room. This effect of varied intensity is obtained by placing the lighting units relative to the machines. The maximum intensity is thus delivered from the correct direction and the spread of light

takes care of the surrounding areas. Such a system has practically all the advantages of the drop light in getting the light where it is needed and yet the lighting units are not within reach.

The work of charging, tumbling, and cleaning is of a relatively rough nature and requires little discrimination of detail. Distribution should be such that harsh shadows and dark corners will not be the result, and that hatchways and pits will be readily visible.

In the following table are listed the intensities which experience indicates are desirable for various processes in steel mill and foundry work.

Thoroughfares	0.1 - 0.5
Ore yards	0.1 - 0.5
Loading yards (no inspection)	0.25- 1.0
Loading yards (inspection)	0.25- 1.0
Open hearth mould yards	0.25- 1.0
Stock houses	0.5 - 1.0
Open hearth charging floors	1.0 - 2.0
Open hearth casting floors	1.0 - 2.0
Soaking pits	1.0 - 2.0
Reheating furnaces	2.0 - 4.0
Puddling furnaces	2.0 - 4.0
Annealing furnaces	2.0 - 4.0
Blast furnaces	1.0 - 2.0
Cast houses	1.0 - 2.0
Mixing houses	2.0 - 4.0
Bessemer (converter houses)	1.0 - 2.0
Bessemer (blower's platform)	3.0 - 6.0
Ingot stripping	1.0 - 2.0
Blooming mills	2.0 - 4.0
Cooling tables	2.0 - 4.0
Rail and structural mills	2.0 - 4.0
Pipe and tube mills	2.0 - 4.0
Chipping	4.0 - 8.0
Hot mills	2.0 - 4.0
Cold rolling	4.0 - 8.0
Shearing (close)	8.0 -12.0
Inspection (general)	4.0 - 8.0
Wire drawing	4.0 - 8.0
Pipe threading	4.0 - 8.0
Nail making	4.0 - 8.0
Pickling	2.0 - 4.0
Tinning	4.0 - 8.0
Tin plate sorting and inspecting	10.0 -15.0
Warehouses	2.0 - 4.0
Shipping	3.0 - 6.0
Machine shops	4.0 - 8.0
Power houses	4.0 - 8.0
Layout and fabrication (structural steel)	4.0 - 8.0
Foundries:	
Floor moulding and casting:	
Heavy castings	4.0 - 6.0
Small castings	6.0 -12.0
Bench moulding and core making	8.0 -12.0
Charging tumbling and cleaning	3.0 - 6.0

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